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TITLE: Integrated Management of Soil Borne Diseases and Aphid Transmitted Viruses in California Vegetable Crops—An on Farm Demonstration

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ABSTRACT:

Reflective plastic mulches reduced the incidence of landing by adult aphids, leafhoppers, and whiteflies in squash and corn. This reduction in the incidence of landing resulted in a delay in the buildup of aphid and whitefly populations and significantly decreased the incidence of corn stunt disease in sweet corn. We also evaluated several new generation insecticides as well as current recommended materials to determine if they would enhance or prolong the effect of the reflective mulches. Yields of sweet corn, both pounds of marketable ears per plot and mean number of ears per plot were significantly higher in all mulch plots than in the unmulched control. Admire, applied as a pre-plant soil treatment without reflective mulch, was significantly less effective in preventing colonization by alate aphids than was reflective mulch alone. As in previous years, the metalized reflective mulch was very effective in repelling silverleaf whitefly adults early in the plant growth cycle. None of the insecticides significantly enhanced the reduction in silverleaf symptoms that were afforded by the mulch alone

PROJECT SUMMARY:

A number of reflective mulches were evaluated for their ability to repel aphids, whiteflies, and corn stunt leafhopper. Treatments (mulches and/or insecticides) were arranged in a randomized complete block design with 6 replications. Plants were grown on raised beds over which the plastic had been placed and anchored around the edges with soil. Mulches evaluated in 1 or more trials included: 1) silver embossed polyethylene (AEP), 2) aluminum metalized polyethylene--Colorup (Specialty Ag), 3) red polyethylene (Sonoco), 4) aluminum metalized polyethylene (Sonoco), 5) black polyethylene (Sonoco), 6) clear polyethylene. Colorup and the Sonoco mulches both cast the appearance of aluminum foil. In addition, several new generation insecticides were evaluated in conjunction with the reflective mulches to determine if the effectiveness of the mulches could be extended or improved by using low rates of very selective insecticides. Insecticides evaluated included: Thiodan, Knack, Admire, Fulfill, and Actara in the squash trial and Lannate in the second corn trial. Yields of sweet corn, both pounds of

marketable ears per plot and mean number of ears per plot were significantly higher in all mulch plots than in the unmulched control. Individual ears from all mulched plots were also heavier than were those from the unmulched plot. These data support the notion that production can be increased approximately 2 fold by growing plants over some type of plastic mulch even in the absence of insect or disease pressure. The Admire plots, (applied to squash) in the absence of reflective mulch, had significantly lower silverleaf whitefly adult densities than did the plot with no mulch and no insecticide (control plots). However, Admire added nothing to the efficacy of the reflective mulch when used alone. None of the insecticides significantly enhanced the reduction in silverleaf symptoms that were afforded by the mulch alone

Introduction

Reflective mulches have been used successfully to reduce and/or delay the incidence of aphid and whitefly colonization and to delay the onset of aphid-borne virus diseases (Summers et al. 1996, Stapleton and Summers 1995; 1997, Summers and Stapleton 1998). Summers and Stapleton (1998) also found reflective mulch repelled corn stunt leafhopper resulting in increased growth and yield of sweet corn. However, reflective mulches cease to repel insects after 60+ % of the surface is covered by the plant canopy (Maelzer 1986). At that point, the incidence of virus diseased and whitefly infested plants rises sharply (Summers et al. 1996, Summers and Stapleton 1998). While yields from crops grown over mulches are significantly above those from crops grown over bare soil, added protection would likely increase yields even higher. Insecticides, by themselves, are ineffective in virus control (Gibson and Rice 1989) and offer little relief for whitefly suppression (Costa et al. 1993). During 1998, we continued our studies on the efficacy of reflective mulches in the management of vegetable insects and also evaluated several new generation insecticides to determine if, when used in conjunction with reflective mulches, the suppression of invading insects and/or the virus diseases they transmit could be extended.

Material and Methods

Treatments (mulches and/or insecticides) were arranged in a randomized complete block design with 6 replications. Plants were grown on raised beds over which the plastic had been placed and anchored around the edges with soil. Plots were 3 rows wide by 30 feet long and separated from adjacent plots by 10 feet of bare soil. The center row was used for all data collection and the two outside rows remained as guard rows. Mulches evaluated in 1 or more trials included: 1) silver embossed polyethylene (AEP), 2) aluminum metalized polyethylene--Colorup (Specialty Ag), 3) red polyethylene (Sonoco), 4) aluminum metalized polyethylene (Sonoco), 5) black polyethylene (Sonoco), 6) clear polyethylene. Colorup and the Sonoco mulches both cast the appearance of aluminum foil. Insecticides evaluated included: Thiodan, Knack, Admire, Fulfill, and Actara in the squash trial and Lannate in the second corn trial. All other insecticides were applied as foliar sprays using a CO₂ powered backpack sprayer equipped with 8002 T-jet nozzles in the equivalent of 20 gallons of water per acre. No insecticides were use in the first corn trial. In the second trial, Lannate was applied on 4 and 16 September and 1 October at 0.50 lbs. (AI)/acre. In the squash trial, Admire, at 16 oz/acre was applied as a pre-plant injection ca. 2-3 inches deep into the center of the planting beds the day before seeding. All other insecticides were applied as foliar sprays using a CO₂ powered backpack sprayer equipped with 8002 T-jet

nozzles in the equivalent of 20 gallons of water per acre. The first application (Fulfill @ 0.045 lbs. (AI)/ acre, Actara @0.045 lbs. (AI)/acre, Thiodan @ 0.75 lbs. (AI)/acre, and Knack @ 0.09 lbs. (AI)/acre) was made on 25 Sept. at 50% canopy coverage. A second application (application (Fulfill @ 0.045/ acre, Thiodan @ 0.75/acre and Knack @ 0.09/acre was made on 19 Oct.

Alate aphids and adult whiteflies were counted by selecting the youngest fully expanded leaf on each plant, gently turning it over, and counting the number of individuals present on the underside. Whitefly nymphs were accessed by selecting a 2-3 week old leaf from each plant, placing it in a ziplock bag, and returning it to the laboratory where the number of individuals were counted. Following counting, the leaves were processed through a LiCor leaf area meter to determine leaf size. Corn stunt leafhoppers populations were determined by taking 25 D-vac samples per plot and returning the bags to the laboratory where the number of leafhoppers were counted. Data were processed by ANOVA and means separated by Fisher's LSD.

Results and Discussion

Sweet Corn. Two corn trials were conducted in 1998, the first trial was planted on 24 April and the second on 12 August. The April planting matured before corn stunt leafhopper populations developed. There were no insect or disease problems noted in the April planting and differences are due principally to the effects of the mulches (Table 1). Yields, both pounds of marketable ears per plot and mean number of ears per plot were significantly higher in all mulch plots than in the unmulched control. Individual ears from all mulched plots were also heavier than were those from the unmulched plot. These data support the notion that production can be increased approximately 2 fold by growing plants over some type of plastic mulch even in the absence of insect or disease pressure.

Table 1. Mean yield per plot, number of ears per plot, weight per year, and mean ear length of sweet corn, cv. Silver Queen, grown over selected plastic mulches. Trial number 1, planted 24 April, harvested 20 July 1998. Parlier, CA.

Mulch Type	Mean Yield (Pounds)/Plot ¹	Mean Number of Ear/Plot ¹	Mean Weight (Pounds)/Ear ¹	Mean Ear Length (In.) ¹
Red	24.40 bc	34.17 bc	0.45 b	7.2 a
Black	25.90 c	34.83 bc	0.45 b	7.3 a
White	19.99 bc	29.17 bc	0.43 b	7.2 a
Clear	24.63 bc	35.83 bc	0.46 b	7.3 a
Colorup	18.80 b	27.33 b	0.39 b	7.1 a
AEP	25.56 c	36.83 c	0.45 b	7.2 a
Control	9.06 a	14.67 a	0.24 a	7.3 a

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

A second trial was planted 12 August. Corn stunt leafhopper is generally more prevalent in the late summer and early fall. The number of corn stunt leafhoppers, potato leafhoppers, and thrips (species not determined, but probably western flower thrips) from plants grown over selected plastic mulches is shown in Table 2 (Table 3). Three sprays with Lannate were not effective in reducing corn stunt leafhopper densities. The level of corn stunt disease was significantly higher in the sprayed plot than in the unsprayed control. Similar results have been reported in the past where insecticides have lead to an increase the incidence of insect-borne virus diseases in may

crops. The metalized mulches, Colorup and Sonoco, appeared to be more effective than the red or AEP mulches.

We also observed some significant differences in the densities of potato leafhopper and thrips although the numbers were more highly variable than those observed for corn stunt leafhopper (Table 2). The data are presented only to stimulate discussion and encourage additional research or observations. Reductions on the 11 September sample date were generally greater than on other sample dates. By the second sample date, plants were beginning to cover the canopy and it is known that reflective mulches lose much of their effectiveness when 50-60% of their surface is covered by the plant canopy. At this point, insufficient data are available to determine if these mulches are really effective in reducing densities of potato leafhopper or thrips. Additional studies will be necessary to determine if these insects can be managed by using reflective mulches.

Table 2. Mean number of corn stunt leafhoppers, potato leafhoppers, and thrips per 25 D-vac samples taken from sweet corn, cv Silver Queen, grown over selected plastic mulches. Trial number 2 planted 12 August 1998. Parlier CA.

Mulch Type	Sample Date	Mean No. Corn Stunt Leafhoppers	Mean No. Potato Leafhopper	Mean No. Thrips
Colorup	11 Sept.	8.33 a	4.33 a	3.00 a
Sonoco	11 Sept.	12.17 ab	5.33 ab	2.00 a
Red	11 Sept.	20.17 bc	12.17 c	6.17 ab
AEP	11 Sept.	18.33 abc	10.33 bc	6.50 ab
Unmulched	11 Sept.	35.83 d	13.00 c	5.67 ab
Unmulched + Lannate ²	11 Sept.	28.83 cd	10.83 c	7.50 b
Colorup	16 Sept.	6.17 a	5.00 a	4.33 a
Sonoco	16 Sept.	15.83 ab	9.17 ab	6.67 ab
Red	16 Sept.	35.50 bc	12.17 ab	14.67 abc
AEP	16 Sept.	19.17 ab	16.17 b	17.17 c
Control	16 Sept.	50.33 cd	11.33 ab	16.50 c
Unmulched + Lannate ²	16 Sept.	61.67 d	11.83 ab	21.50 c
Colorup	23 Sept.	37.17 a	14.83 a	20.67 a
Sonoco	23 Sept.	31.67 a	18.83 ab	19.50 a
Red	23 Sept.	138.83 c	27.33 b	33.83 a
AEP	23 Sept.	73.00 ab	24.67 b	21.00 a
Control	23 Sept.	170.83 c	18.50 ab	15.33 a
Unmulched + Lannate ²	23 Sept.	121.22 bc	20.00 ab	12.83 a

²Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD. Comparisons are valid only within sample dates and columns of individual insects and not between sample dates or across rows.

Table 3. Percentage of corn plants infected with corn stunt disease. Trial number 2. Planted 12 August, harvested 4 November 1998.

Mulch Type	Percent Infected Plants
Colorup	0.00 a
Sonoco	1.98 a
Red	2.00 a
AEP	0.00 ac
Control	23.28 b
Unmulched + Lannate ²	30.49 c

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

²Lannate applied on 4 and 16 September and 1 October at 0.50 lbs/acre (AI) in the equivalent of 20 gallons water per acre.

Yields (pounds of marketable ears) from plants grown over the three reflective mulches were significantly higher than from those grown over red mulch, unmulched, or the unmulched plus insecticide treated plots (Table 4). Maximum yields were obtained from plots with metalized mulch. There was basically no difference in the number of ears per plot among the treatments, but ears from plants grown over the reflective mulches were fuller than those from the other treatments as indicated by heavier ear weights and had larger kernels (Table 4). Mean ear length was basically not affected by mulch type. Mean stalk weight, an indication of yield in field corn processed for silage, was significantly lower in the unmulched and unmulched plus insecticide plots than in the mulched plots (Table 4). This can be attributed to the significantly higher incidence of infection by the corn stunt disease in these plots (Table 3).

Table 4. Mean yield per plot, mean number of ears per plot, mean weight per ear and mean ear length in sweet corn, cv Silver Queen, grown over selected plastic mulch. Trial number 2. Planted 12 August, harvested 4 November 1998.

Mulch Type	Mean Yield (Pounds)/Plot ¹	Mean Number of Ear/Plot ¹	Mean Weight (Pounds)/Ear ¹	Mean Ear Length (In.) ¹	Mean Stalk Weight (Pounds) ¹
Colorup	30.40 c	45.5 b	0.40 c	7.84 bc	66.40 c
Sonoco	35.57 d	46.5 b	0.42 c	8.00 c	64.53 c
Red	24.03 a	42.5 ab	0.35 a	7.51 a	55.71 b
AEP	29.81 bc	45.33 b	0.39 bc	7.81 bc	59.72 bc
Control	25.58 ab	44.67 b	0.36 ab	7.82 bc	36.83 a
Unmulched + Lannate ²	23.46 a	38.17 a	0.32 a	7.68 ab	36.65 a

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

²Lannate applied on 4 and 16 September and 1 October at 0.50 lbs/acre (AI) in the equivalent of 20 gallons water per acre.

Squash. Aphids. The metalized mulch Colorup was used, since in previous studies no differences were found among any of the metalized mulches tested relative to their effectiveness in repelling alate aphids or adult whiteflies. (Stapleton and Summers 1996, 1997; Summers and Stapleton, 1998). Admire, applied as a pre-plant soil treatment without reflective mulch, was significantly less effective in preventing colonization by alate aphids than was Colorup alone

during early plant growth. (Table 5). The higher rate of colonization in the Admire plots during the early growth period is sufficient to allow the introduction of viruses during the critical early growth stage. Foliar insecticide applications were made between September 21 and 28, a point at which the plant canopy covered approximately 50-60% of the mulch surface. In samples taken 3 days later, none of the foliar sprays were effective in reducing alate aphid population to levels equivalent to the metalized mulches or Admire (Table 5). Seven days later, control with Fulfill and Actara was significantly better than with in the untreated/unmulched control and with Knack. In general, none of the insecticides in the absence of the mulch, preformed as well as they did with mulch or as well as the mulch alone. By 12 October, all treatments were significantly better than the unmulched/unsprayed control. By this time however, aphid populations were declining and it is difficult to draw meaningful conclusions. Because of low numbers, no conclusions can be drawn regarding the second insecticide application.

Table 5. Mean number of alate aphids/leaf on squash plants grown over Colorup mulch with and without selected insecticides.

Treatment ²	Sampling Date							
	September				October			
	14	21 ↓	28	5	12	19 ↓	21	23
Colorup	0.2 a	0.4 a	0.1 ab	0.1 a	0.2 a	0.1 ab	0.1 ab	0.1 a
Colorup + Fulfill (1 Appl.)	-	-	0.2 ab	0.1 a	0.1 a	0.1 ab	0.1 a	0.1 a
Colorup + Fulfill (2 Appl.)	-	-	0.0 a	0.1 a	0.0 a	0.0 a	0.1 a	0.1 a
Colorup + Actata	-	-	0.2 ab	0.1 a	0.2 a	0.1 ab	0.0 a	0.1 a
Colorup + Admire	0.2 a	0.0 a	0.0 a	0.1 a	0.2 a	0.1 ab	0.1 ab	0.1 a
Unmulched + Admire	2.6 b	1.6 b	0.2 ab	0.2 ab	0.2 a	0.2 b	0.3 c	0.2 bc
Unmulched + Fulfill (1 Appl.)	-	-	0.7 bc	0.8 cd	0.4 a	0.1 ab	0.2 bc	0.1 a
Unmulched + Fulfill (2 Appl.)	-	-	1.3 cd	0.5 bc	0.4 a	0.1 ab	0.1 ab	0.15 ab
Unmulched + Actara	-	-	0.8 bc	0.3 abc	0.4 a	0.1 ab	0.1 ab	0.1 a
Unmulched + Thiodan (2 Appl.)	-	-	0.7 bc	0.6 bcd	0.3 a	0.1 ab	0.0 a	0.1 a
Unmulched + Knack (2 Appl.)	-	-	2.1 d	1.2 e	0.4 a	0.1 ab	0.1 ab	0.15 ab
Control	4.1 c	3.4 c	1.2 c	1.0 de	1.0 b	0.4 c	0.1 ab	0.3 c

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

Whiteflies. As in previous years, the metalized reflective mulch was very effective in repelling silverleaf whitefly adults early in the plant growth cycle (Table 6). The Admire plots, in the absence of reflective mulch, had significantly lower silverleaf whitefly adult densities than did the plot with no mulch and no insecticide (control plots) (Table 6). However, Admire added nothing to the efficacy of the reflective mulch when used alone (Table 6). A foliar spray with Knack was ineffective in reducing adult silverleaf whitefly populations (Table 6). Foliar applications of Fulfill, Actara, and Thiodan significantly reduced adult silverleaf whitefly densities 3 days after application (Table 6). The control with Fulfill and Actara appeared to hold up fairly well over the following 3 week period while Thiodan lost effectiveness after 10 days. A second application of Fulfill, Thiodan, and Knack was made on 19 October. All materials except Knack again provided adequate control (Table 6). In the absence of reflective mulch, only Admire was effective in reducing the density of silverleaf whitefly nymphs (Table 7). None of the insecticides significantly enhanced the control afforded by the mulch alone.

Table 6. Mean number of silverleaf whitefly adults per leaf on squash plants grown over Colorup mulch with and without selected insecticide treatments¹.

Treatment	Sampling Date							
	September				October			
	14	21	28	5	12	19	21	23
Colorup	1.1 a	3.6 a	1.4 ab	1.0 ab	6.1 ab	10.2 bcde	5.4 abc	8.9 bcd
Colorup + Fulfill (1 Appl.)	-	-	2.2 ab	0.7 ab	2.9 ab	6.2 bc	6.7 abc	7.4 abc
Colorup + Fulfill (2 Appl.)	-	-	1.6 ab	1.1 ab	5.0 a	6.1 abc	4.9 abc	6.8 abc
Colorup + Actara	-	-	0.5 a	0.3 a	5.1 a	4.9 abc	5.6 abc	7.5 abc
Colorup + Admire	1.4 a	1.3 a	0.4 a	0.2 a	1.3 a	0.3 a	0.2 a	1.7 a
Unmulched + Admire	9.3 b	4.4 a	2.2 b	0.7 ab	4.4 a	0.7 a	0.8 ab	3.7 ab
Unmulched + Fulfill (1 Appl.)	-	-	17.8 bcde	8.6 cd	17.4 bc	19.8 f	13.4 de	15.2 de
Unmulched + Fulfill (2 Appl.)	-	-	18.1 bcde	5.9 cd	16.0 bc	8.4 abcd	5.6 abc	7.8 abc
Unmulched + Actara	-	-	3.3 abc	5.1 bcd	16.5 bc	12.8 cdef	4.4 abc	12.9 cde
Unmulched + Thiodan (2 Appl.)	-	-	9.7 abcd	4.0 abc	23.1 cd	17.3 def	10.3 cd	2.6 ab
Unmulched + Knack (2 Appl.)	-	-	32.1 e	15.7 e	28.3 d	19.8 f	17.3 e	23.3 f
Control	17.4 c	31.8 b	21.8 c	9.8 d	24.3 cd	18.8 ef	10.3 cd	17.1 ef

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

Table 7. Mean number of silverleaf whitefly nymphs per cm² of squash leaf. Leaves were selected from plants grown over Colorup mulch with and without selected insecticide treatments¹.

Treatment	Sampling Date		
	September		October
	21	28	5
Colorup	0.002	0.9 a	1.2 a
Colorup + Fulfill (1 Appl.)	-	1.0 a	1.6 a
Colorup + Fulfill (2 Appl.)	-	0.4 a	1.2 a
Colorup + Actara	-	0.8 a	1.7 a
Colorup + Admire	0.001 a	0.2 a	0.2 a
Unmulched + Admire	0.011 b	1.1 a	1.1 a
Unmulched + Fulfill (1 Appl.)	-	37.3 b	34.0 c
Unmulched + Fulfill (2 Appl.)	-	14.0 b	22.5 bc
Unmulched + Actara	-	4.4 ab	8.4 ab
Unmulched + Thiodan	-	9.3 b	12.9 bc
Unmulched + Knack	-	30.3 b	21.6 bc
Control	0.011 b	20.8 b	22.5 ab

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

Silverleaf Symptoms. The percentage of plants showing symptoms of squash silverleaf was determined on the final harvest date, 15 November, by visual inspection. The incidence of squash silverleaf was significantly reduced by the metalized reflective mulch (Table 8.). Admire, as a stand alone treatment, was as effective as the mulch or the mulch + Admire combination in reducing the incidence of squash silverleaf. This is readily apparent from the nymphal densities shown in Table 7. None of the insecticides significantly enhanced the reduction in silverleaf symptoms afforded by the mulch alone (Table 8).

Table 8. Incidence of squash silverleaf in plants grown over a metalized reflective mulch with and without selected insecticide treatments¹.

Treatment	Per Cent of Plants With Silverleaf Symptoms
Colorup	0.5 a
Colorup + Fulfill (1 Appl.)	4.2 a
Colorup + Fulfill (2 Appl.)	6.5 a
Colorup + Actara	0.3 a
Colorup + Admire	0.3 a
Unmulched + Admire	3.5 a
Unmulched + Fulfill (1 Appl.)	87.7 c
Unmulched + Fulfill (2 Appl.)	89.4 c
Unmulched + Actara	74.1 bc
Unmulched + Thiodan	54.5 b
Unmulched + Knack	50.5 b
Control	87.7 c

¹Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

Yields. Total accumulated yield of marketable fruit harvested over 15 dates are shown in Table 9. The results clearly show that the metalized reflective mulch was the key to producing increase yields. The mulch alone was as effective as any of the mulch plus insecticide treatments and significantly more effective than any of the insecticide treatments in absence of the mulch

Table 9. Mean cumulative yield¹ (pounds per plot) of squash grown over reflective metalized mulch with and without selected insecticide applications²

Treatment	Total Pounds of Marketable Fruit per Plot
Colorup	26.0 c
Colorup + Fulfill (1 Appl.)	24.5 c
Colorup + Fulfill (2 Appl.)	23.9 c
Colorup + Actara	27.5 c
Colorup + Admire	22.5 c
Unmulched + Admire	9.0 ab
Unmulched + Fulfill (1 Appl.)	6.5 ab
Unmulched + Fulfill (2 Appl.)	8.3 ab
Unmulched + Actara	10.7 b
Unmulched + Thiodan	6.3 ab
Unmulched + Knack	7.9 ab
Control	5.1 a

¹ Total of 15 harvest dates. Harvest made approximately every other day.

²Means followed by the same letter(s) are not significantly different, $P < 0.05$. Fisher's LSD.

Summary and Conclusions

Many vegetable crops are high consumers of pesticides, with material sometimes sprayed every few day for control of aphids and whiteflies. In order to determine if these insects, and in some cases the diseases that they transmit could be managed we evaluated several reflective plastic mulches to determine their effectiveness in repelling aphids, leafhoppers, and whiteflies from selected vegetable crops. We also evaluated several new generation insecticides to determine if the effectiveness of the reflective mulches could be extended or enhanced by their use. Corn yields from the first experiment, both pounds of marketable ears per plot and mean number of ears per plot were significantly higher in all mulch plots than in the unmulched control. Individual ears from all mulched plots were also heavier than were those from the unmulched plot. These data support the notion that production can be increased approximately 2 fold by growing plants over some type of plastic mulch even in the absence of insect or disease pressure. The data from the second corn experiment clearly show that the reflective mulches, Colorup, Sonoco, and AEP were effective in repelling corn stunt leafhopper thereby reducing population levels on the plants. Even the red plastic, for as yet unknown reasons appeared to repel corn stunt leafhoppers early in the season. Reduction in corn stunt leafhopper number is also reflected in the decrease in the number of plants infected with corn stunt sprioplasm. Yields (pounds of marketable ears) from plants grown over the three reflective mulches were significantly higher than from those grown over red mulch, unmulched, or the unmulched plus insecticide treated plots. Maximum yields were obtained from plots with metalized mulch.

Reflective mulch was effective in repelling aphids and whiteflies from squash plants resulting in significantly higher fruit yields for these plots. Admire, applied as a pre-plant soil treatment without reflective mulch, was significantly less effective in preventing colonization by alate aphids than was reflective mulch alone. As in previous years, the metalized reflective mulch was very effective in repelling silverleaf whitefly adults early in the plant growth cycle. The Admire plots, in the absence of reflective mulch, had significantly lower silverleaf whitefly adult densities than did the plot with no mulch and no insecticide (control plots). However, Admire added nothing to the efficacy of the reflective mulch when used alone). Foliar applications of Fulfill, Actara, and Thiodan significantly reduced adult silverleaf whitefly densities 3 days after application. The control with Fulfill and Actara appeared to hold up fairly well over the following 3 week period while Thiodan lost effectiveness after 10 days. In the absence of reflective mulch, only Admire was effective in reducing the density of silverleaf whitefly nymphs. None of the insecticides significantly enhanced the control afforded by the mulch alone. None of the insecticides significantly enhanced the reduction in silverleaf symptoms afforded by the mulch alone. Metalized reflective mulch was the key to producing increase yields. The mulch alone was as effective as any of the mulch plus insecticide treatments and significantly more effective than any of the insecticide treatments in absence of the mulch.

Reflective plastic mulches have been shown to provide excellent management of aphids, aphid borne viruses, silverleaf whitefly, corn stunt leafhopper and perhaps *Empoasca* sp. leafhoppers

and thrips on a wide range of vegetables. Reflective mulches have been found to be significantly more effective in insect and virus disease pest management than any insecticide treatments.

REFERENCES CITED

1. Costa, H. S., J. K. Brown, S. Sivasupramaniam, and J. Bird. 1993. Regional distribution, insecticide resistance and reciprocal crosses between the 'A' and 'b' types of *Bemisia tabaci*. *Insect Sci. Appl.* 14: 127-138.
2. Gibson, R. W., and A. D. Rice. 1989. Modifying aphid behavior. pp. 209-224. *In: Aphids, their biology, Natural enemies, and control* Vol. 2C A. K. Minks and P. Harrewijn [eds.]. Elsevier, Amsterdam.
3. Maelzer, D. A. 1986. Integrated control of insect vectors of plant virus diseases. pp. 483-512. *In: Plant virus epidemics-monitoring, modeling and predicting outbreaks.* D. L. McLean, R. G. Garrett, and W. G. Ruesink. [eds.]. Academic Press, New York.
4. Stapleton, J. J., and C. G. Summers. 1995. Reflective mulches repel aphids and protect cucurbitaceous crops from virus diseases. *UC Plant Prot. Quart.* 5(1): 4-6.
5. Stapleton, J. J., and C. G. Summers. 1997. Reflective mulches for managing aphids, aphid-borne viruses, and silverleaf whitefly: 1996 Season Review. *UC Plant Prot. Quart.* 7(1): 1-5.
6. Summers, C. G., J. J. Stapleton, A. S. Newton, R. A. Duncan, and D. Hart. 1996. Comparison of sprayable and film mulches in delaying the onset of aphid-transmitted virus diseases in zucchini squash. *Plant Dis.* 79: 1126-1131.
7. Summers, C.G., and J. J. Stapleton. 1998. Management of vegetable insects using plastic mulch: 1997 Season Review. *UC Plant Prot. Quart.* 8 (1 & 2): 9-11.

FIELD DAYS:

October 14, 1999. Field Demonstration of Reflective Mulches and Insecticides in the Management of Aphids, Leafhoppers, and Whiteflies of Selected Vegetable Crops. Kearney Agricultural Center, Parlier, CA.

October 17, 1999. Use of Reflective Mulches in the Management of Aphids, Leafhoppers, and Whiteflies of Selected Vegetable Crops. University of California Plant Protection Class. Kearney Agricultural Center, Parlier, CA.

PUBLICATIONS:

Summers, C. G., and J. J. Stapleton. 1999. Management of aphids, silverleaf whiteflies and corn stunt leafhopper using reflective plastic mulch and insecticides. 1998 season review. UC Plant Protection Quarterly. 9(1):2-7.

Summers, C. G., and J. J. Stapleton. 1998 Management of vegetable insects using plastic mulch. 1997 season review. Plant Protection Quarterly. 8 (1-2): 9-11.

Summers, C. G., 2000. Reflective Mulches. In. D. Pimentel [ed.]. Encyclopedia of Pest Management. Marcel-Decker. NY. In Press.

Summers, C. G., and J. J. Stapleton. 1999. Management of Vegetable Insects Using Reflective Mulches. Research Trends in Entomology. In Press.

Summers, C. G., and J. J. Stapleton. 1999. Management of silverleaf whitefly, *Bemisia argentifolii*, melon aphid, *Aphis gossypii*, and virus diseases in vegetables using reflective plastic mulches. In. Proc. Of the XIV International Plant Protection Congress, Jerusalem, Israel, In Press.

Stapleton, J.J., M. A. Mahmoudpour, and C. G. Summers. 1998. Influence of spray mulch color on yield of eggplant in the San Joaquin Valley. Proc. National Agric. Plastics Cong. 27: 210-214.

Davis, R. M., J. E. DeVay, T. R. Gordon, and J. J. Stapleton. 1998. Diseases. In. Integrated Pest Management for Tomatoes. 4th Ed. University of California, Statewide Integrated Pest Management Project. Division of Agricultural and Natural Resources, Publication 3274.

Mahmoudpour, M. A., and J. J. Stapleton. 1998. Influence of sprayable mulch surface color on growth and yield of eggplant. In Proc. 19th Annual Central California Research Symp. California State University, Fresno.

Stapleton, J. J., and C. G. Summers. 1998. Integrated pest management for fresh market tomato (*Lycopersicon esculentum* cv. Shady Lady) using soil solarization and reflectorized plastic mulch. In. J. J. Stapleton, J. E. DeVay, and C. L. Elmore. Eds. Soil Solarization and Integrated Management of Soilborne Pests. FAO Plant Production and Protection Paper. 147: 625-629.

PRESENTATIONS:

Summers, C. G., 1998. Management of Aphids and Whiteflies in Vegetable Crops Using Reflective Plastic Mulch. Entomological Society of America, Pacific Branch Ann. Meeting. Honolulu, HI. June 20-23. 1998.

Summers, C. G., October 14, 1998. Field Demonstration of Reflective Mulches and Insecticides in the Management of Aphids, Leafhoppers, and Whiteflies of Selected Vegetable Crops. Kearney Agricultural Center, Parlier, CA.

Summers, C. G., October 17, 1998. Use of Reflective Mulches in the Management of Aphids, Leafhoppers, and Whiteflies of Selected Vegetable Crops. University of California Plant Protection Class. Kearney Agricultural Center, Parlier, CA.

Stapleton, J. J., October 14, 1998. Field Demonstration of Reflective Mulches and Insecticides in the Management of Aphids, Leafhoppers, and Whiteflies of Selected Vegetable Crops. Kearney Agricultural Center, Parlier, CA.

Stapleton, J. J., 1998. Plastic mulches: What they do and what they don't. UCCE San Benito Co. Vegetable Crops Meeting. Hollister CA. February 3. 1998.

Stapleton, J. J., 1998. Influence of spray mulch color on yield of eggplant in the San Joaquin Valley. 27th National Agricultural Plastic Congress, Tucson, AZ. Feb. 20, 1998.

Stapleton, J. J., 1998. Use of mulches in plant disease management. UC Davis Plant Pathology Class. Kearney Agricultural Center. June 30. 1998.

Stapleton, J. J., 1998. WC Workshop on Light and Temperature Effects in Permanent Crops. Kearney Agricultural Center, July 7. 1998.

Stapleton, J. J., 1998. Influence of light intensity on late-season field production of *Zinnia elegans* in the San Joaquin Valley: Preliminary Results. California Nurserymen's Assoc. Research Meeting. Buena Park, CA. July 9, 1998.

Stapleton, J. J., 1998. Developing an IMP program for aphid-transmitted virus diseases in the San Joaquin Valley. Joint Mgt. Entomological Society of America and Phytopathological Society of America. Las Vegas NV. November. 10, 1998.

Stapleton, J. J., 1999. Use of latex mulches. II Forum on the Cultivation of Melon. University of Colima, Ixlahuacan Mexico.

APPENDIX 1

POPULAR PRESS:

Reflective Mulches Shine—New Data Shows Significant Benefits. Patrick Cavanaugh, Vegetables West—Grower & PCA. Vol. 3, No. 2. February 1999. -----Copy Attached-----



About the Cover: *Central Valley Broccoli nearing harvest.*

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Reflective Mulches Shine

New Data Shows Significant Benefits

By Patrick Cavanaugh, Editor



At a recent field day, growers and PCAs look over the various mulches used in the trial.

It began with earlier work with reflective sprays but has evolved into reflective (metalized) plastic mulches. And with these improvements has been a stepped up control of aphids and whiteflies by deterring their landing on plant tissues.

The remarkable research was begun several years back by Charlie

Summers, UC Davis Associate Entomologist and James Stapleton, UC Regional IPM Advisor. Both are stationed at the UC Kearney Ag Station in Parlier where they are studying the effects of metalized and grey plastic mulches on pest control.

Virus transmitting aphids were the priority pest in the research, but ben-

efits are also being seen in the control of whitefly, lygus and other pests and diseases.

"Aphids transmit viruses in a few seconds and it's difficult to stay on top of them flying across a field," said Stapleton.

"You can control aphids with sprays, but you can't control the virus they transmit," said Summers. "The virus transmission happens in a short time interval."

Summers noted that spraying may cause even more virus transmission. "There is substantial data indicating that spraying makes matters worse because the nerve poison agitates the aphid, causing it to jump from plant to plant, transmitting a lot of viruses before it dies."

The control mechanism centers on the different wavelengths of light. Aphids and whiteflies zero-in on green and yellow light emitted from plant tissues. That's their food source. They are repelled by the UV light found in the sky.

On bare soil, without the reflective mulch, the UV is absorbed by the soil leaving the green and yellow plant tissue visible for the aphids. In the presence of the reflective mulches, the UV wavelengths are bounced back toward the sky. "That's what the aphid 'sees' when flying over the field," said Summers. "He's repelled by

Across the board the reflective mulches worked better than bare soil when it came to protecting plants from aphids.



the UV wavelength that is being bounced back by the mulches."

The study involved several plastic mulches broken down into two categories. One is a metalized plastic mulch which is highly reflective and looks like aluminum foil. In the data, this material is known as silver mulch.

Another material used has less reflective properties and is known as a grey mulch. For aphids, the grey mulches seemed to work as well as the silver, but for whiteflies the silver mulch worked significantly better.

The researchers saw some positive effects on reflective mulches on the growth of melons as well. "These are side benefits," said Summers. "There are growth enhancements even in the absence of insect and disease pressure. The hypothesis is because of the extra light being bounced around, there is an increase in photosynthesis.

The mulch also conserves water and reduces weed infestation.

When applying the reflective mulches, keep in mind that every row has a maximum effect. Every other

Summary of Melon Yields

Treatment	Cartons Per a Acre Continuous
Row Silver	699
Continuous Row Grey	625
Alternate Row Silver	416
Alternate Row Grey	363
Control (no mulch)	317

Yields in corn were significantly better with the metalized products over the grey material. The Corn Stunt Leafhopper is apparently being repelled. It transmits a bacterial disease called corn stunt disease.

Treatment	Pounds of Ears/Plot	Stalk Length (cm)
Metalized	36.6	79.2
Grey	28.2	73.9
Control	16.3	71.2

Cucumber yields (pounds/plants) for plants growing on reflective mulches versus bare soil for whitefly control.

Metalized	60.6
Control	5.9

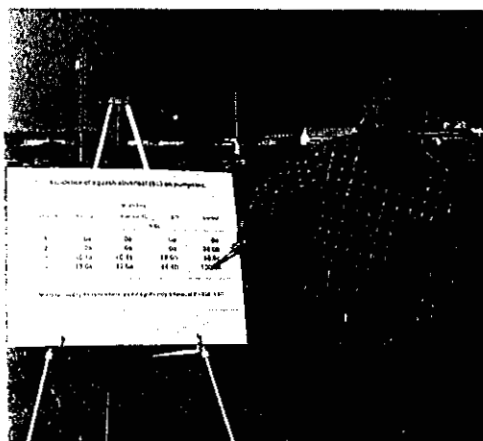
can withstand more pressure.

Crops successfully grown over reflective mulches include cantaloupe, zucchini, pumpkin, eggplant, cucumber, tomato, peppers and corn.

In a 1998 eggplant study the re-

searchers saw a yield increase with reflective mulches along with better aphid, whitefly and lygus control.

The additional light around the eggplant also caused the plant to continue to flower and set fruit.



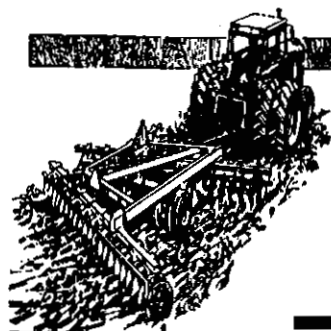
Charlie Summers, UC Davis Associate Entomologist pointing out reflective mulche data.

row can save money, but there is not as much protection.

And it's most effective early in the season when the plants are small and there is more reflective properties before the plant expands out over the mulch.

The researchers noted that it's very important to protect plants early at the young cotyledon stage. Older plants

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